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ELECTRIC POWER ENGINEERING CENTRE

# Electric Power R&D in New Zealand -'Power Up or Power Down'

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**SYNOPSIS:**

Based on the experience of the Electric Power Engineering Centre (www.epecentre.ac.nz), which launched NZ's first industry-academia collaborative electric power R&D programme in 2005, there are currently a number of critical areas in electric power engineering in NZ requiring particular research attention. This paper discusses challenges and obstacles that must be overcome to facilitate this research, as well as opportunities for collaboration between the NZ electric power industry, government and academia.

According to the Ministry of Research, Science & Technology (MoRST) Energy Roadmap, NZ has a unique mix of energy resources, energy infrastructure, needs and energy efficiency opportunities. The significance of this is that international research will not provide all the detailed answers for NZ to help meet future needs in electricity supply – "it must be done by us, for us, to find customized solutions". Moreover, we are a nation that is more and more heavily dependent on electricity supply for all sectors of industry and community. The quality of electricity supply affects almost all markets without exception and electricity itself accounts for approximately 3% of total GDP p.a. or roughly NZ$4 billion p.a. (from 2007 GDP data). Currently, total government expenditure on energy R&D is estimated to be $18 million, which is 1% of total annual R&D spending in NZ ($1.8 billion p.a.).

This paper examines if this is sufficient or should NZ be investing more public funding into energy R&D, or perhaps it is up to the electricity industry to pick up where the government has left off, especially given NZ's bold new target of 90% renewable by 2025? Areas identified that require research include the network integration of variable energy sources (e.g. wind power) and affects of variable loads on power quality. A range of incentives including the new R&D tax credits and co-funding schemes, particularly for 'industry based' applied research are discussed and recommendations provided. This paper also indicates that the power industry is currently in a strong position to capitalise on these incentives, taking into consideration that solutions for overseas electricity industry (researched overseas) may not be relevant enough to support specific NZ electricity industry conditions and / or scenarios. The discussion concludes by considering the longer term impacts of doing and not doing enough electric power R&D in NZ.

## INTRODUCTION

The Ministry of Research, Science & Technology (MoRST) Energy Roadmap states that NZ has a unique mix of energy resources, energy infrastructure, needs and energy efficiency opportunities. The significance of this is that international research will not provide all the detailed answers for NZ to help meet future needs in electricity supply – *"it must be done by us, for us, to find customized solutions"*. According to Statistics NZ, electricity accounts for approximately 3% of total GDP p.a. or roughly NZ$4 billion p.a. (from 2007 GDP data) and its supply affects almost all markets, without exception. Thus, R&D to ensure quality of electricity delivery is vital for NZ.

Based on the experience of the Electric Power Engineering Centre (www.epecentre.ac.nz), which launched NZ's first industry-academia collaborative electric power R&D programme in 2005, there are currently a number of critical areas requiring particular research attention in the NZ electricity sector. This is taking into consideration that solutions for overseas electricity industry (researched overseas) may not be relevant enough to support specific NZ electricity industry conditions and/or scenarios. Much of this is mainly due to the nature of NZ's unique 'long and narrow' electric power system, with greater demand in the North (i.e. Auckland) and a significant portion of generation in the South, as well as the increasing number of energy efficient technologies being introduced into NZ (e.g. heatpumps, CFLs, etc.).

At present, the government operates a number of funding schemes and initiatives to enable 'industry based' applied research through its various agencies. However, total government (public sector) expenditure on energy R&D is estimated to be $18 million, which amounts to 1% of the $1.8 billion spent annually on all fields of R&D in NZ. Furthermore, much of this 1% is tagged towards specific energy research priorities (blue sky's type) identified by the government, in areas such as hydrogen, wave power, bio-fuels and technology aspects of distributed generation (DG).[1] Meanwhile, current research priorities of the electricity industry seem to be much more focused towards the network integration challenges posed by renewable energies (incl. DG) and customer loads (non-linear/time-varying/static) i.e. affects on power quality.

## WHAT IS R&D?

R&D is defined as the practice of 'discovering new knowledge about products, processes and services, and then applying that knowledge to create new and improved products, processes and services'.[2]

## R&D IN NEW ZEALAND

According to the Prime Minister, Helen Clark, a 'huge' R&D fund for the primary sector is vital for the future of NZ or the nation is at risk of becoming a 3rd World country. The government followed this statement with an announcement of a $700 million, one-off public sector injection into primary production R&D for the agricultural, dairy and meat industries, an initiative supported by dairy co-op Fonterra, Meat & Wool NZ, the Meat Industry Assoc., Zespri (Kiwifruit), Dairy NZ and PGG Wrightson. This fund is expected to grow to $1b through interest earnings over the next decade, a figure which needs to be matched dollar for dollar by the primary production industry. In addition to this, a Crown entity is to be formed to manage these investments, guided by a joint industry-government agency.[3]

Nevertheless, this initiative does raise an intense debate, mainly around the question 'why a sector enjoying record profits and commodity prices, needs taxpayer help?' The government grounds their support on the theory that the primary production industry has been lagging in R&D expenditure and this fund will help encourage industry investment into this area. The opposing view on this is that a great deal of NZ R&D funding will be locked and tagged to projects that may add little or no direct value to the economy, especially in an area many believe has little 'market pull' for commercialisation. Therefore, it is highly probable that this sector of industry spends very little on R&D for this very reason, i.e. the sector does not foresee opportunities for improving profits in a mature market through intense R&D.

This is evident by statements made by the primary production industry itself. For example, the profit barriers for the NZ meat industry, according to PGG Wrightson, is mainly due to the high FOREX rate, interest and drought in the North Island[4], while dairy giant Fonterra claims that returns are currently well above average, with drought being the major concern to affect profits in the future (i.e. acts of God).[5] Thus, within this context, R&D activity does not appear to be a key factor for improved 'future' profits in this particular industry, based on media statements.

However, legislative logic appears to be that NZ is investing in its existing strength, i.e. the spot-light is on the primary production sector (22% of all R&D public spending[24]), which leads to another imminent issue, the progression towards a knowledge-based economy in NZ, alongside other 1st world countries. This implies that the approach should be more flexible and emphasis should be towards developing new knowledge and intellectual property (IP) in a variety of sectors (in whatever shape or form), and development of vital infrastructure to support these knowledge economies, especially 'future-proofing' of electric power systems.

**The Knowledge Economy:**
Various observers describe today's global economy as one in transition to a 'knowledge economy'. The transition requires that the rules and practices that determined success in the industrial economy need rewriting in an interconnected, globalised economy where knowledge resources such as know-how, expertise and IP are more critical than other economies based on commodities such as dairy and meat.[6] Pundits suggest that <u>three key drivers are changing the rules of international business and national competitiveness:</u> [6]

1. **Globalisation—** markets and products are more global.
2. **Information/knowledge Intensity —** performance relies on information and know-how
3. **Connectivity** - developments such as the Internet creating boundary-less communities.

However, the foundation of a 'knowledge economy' is a robust and resilient electricity supply, much of what is envisaged for such an economy is heavily dependent on it. In the words of former Transpower Chief Executive, Dr. Ralph Craven, the electricity power industry is about joining communities and providing the underpinning of the economy, not just wires and pylons.[7] Therefore, electric power <u>R&D</u> to find solutions for <u>relevant industry issues</u> will be key, to pave the way for a future 'knowledge economy' in NZ.

*"Electricity is an enabling technology rather than a product in its own right. We consume electricity to produce something else, unlike food for example, which we consume to live".*

**Current Market Conditions:**

NZ has climbed the global competitive rankings to no.19th, with Australia on 12th in the IMD World Competitiveness Year Book, which ranks countries on their ability to create and sustain enterprise competitiveness. A significant barrier to improvement within this ranking is infrastructural issues such as energy supply.[8]

All manner of land in NZ is currently being converted to dairying at a rapid rate, with short-term profits in mind. NZ's farming and political leaders seem seduced by high dairy prices. Nevertheless, what would happen when dairy prices fall in the face of cheap imports from countries where labour and land are much cheaper and export costs are less, particularly given NZ's remote geographic location,[9] i.e. currently almost all of NZ's eggs are in one basket (i.e. primary production).

Skilled people want to do challenging work – they want to be in organisations doing new and exciting projects (e.g. ground breaking projects). If those opportunities are increasing overseas, that is where the majority of those skilled people will head. Many believe that it is not just about paying people more, it is also about giving them great things to do,[10] i.e. the future of NZ will be dependent on NZ's ability to retain these people, especially to undertake R&D and develop a 'knowledge economy'.

Comparative R&D expenditure amongst developed countries shows that NZ lags behind, well below the OECD average on R&D spending as a percentage of GDP. Industry expenditure on R&D also appears low, as shown in Fig.1.[11]

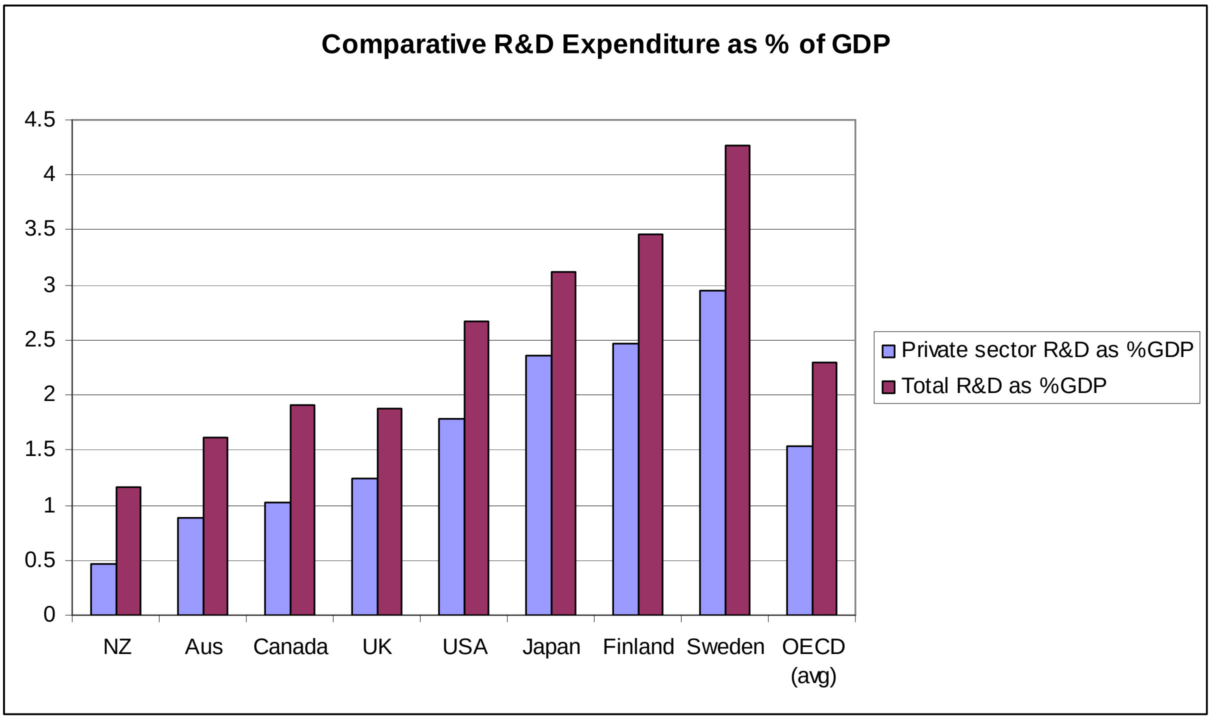


***Fig. 1 Comparative R&D expenditure as a percentage of GDP Based on 2005 data[11]***

The annual Deloitte compilation of performance for the top 200 NZ companies in 2005 (as featured in the NZ Institute of Management Magazine) shows that the power industry players feature prominently under the '20 Biggest Profit Makers' column, with an average of $166,000,000 after-tax profit each for the featured power companies.[11]

**R&D VS ROI**

If investing in innovation (i.e. R&D) is considered too expensive, the alternative could be much worse. In reality, industry strives to best achieve a balance between cutting-edge innovation and rock-solid ROI (Return on Investment). However, there is room for improvement, according to a study conducted by the US based Boston Consulting Group Inc., where a survey was carried out in over 52 countries between 2006 and 2007. The results showed that only 46% of executives were satisfied with ROI on R&D, even with 66% ranking the importance of R&D activity within their organisation's top three strategic priorities. This is a clear indication of the existing trade-off between R&D expenditure and ROI.

In terms of improving this balance, the solution is to undertake feasibility studies at the start to kill off bad ideas, and then do the numbers by analysing risk and reward before moving forward with significant investment. Industry needs to think like venture capitalists when it comes to R&D – fail often, but fail cheaply, i.e. have a lot of ongoing R&D (feasibility projects) but be comfortable about them failing.[12] However, failing in R&D can also be considered a form of success, because of the lessons learned. When it succeeds the rewards can be invaluable. However, 82% of businesses in NZ claim they spend less than 5% of turnover on R&D.[27]

**R&D Dynamics:**

Some of the many considerations for R&D activity includes creating a logical project framework, understanding and respecting differences amongst stakeholders/participants, encouraging involvement at all levels of the organisation, establishing metrics (e.g. feedback), monitoring results, communicating and collaborating with those involved, and remaining flexible and patient.[13]

Another key issue with regard to R&D is to know when to invest. Cutting back on R&D rather than investing is always an easy option. A recent survey has predicted a slowdown in the economy, however general consensus is that the economic downturn will not be that tough and the economy will recover. Unfortunately, industry generally reacts to such movements by cost cutting. This is short term thinking at its worst.[14] One of the first to be cut is the R&D budget.

Intellectual Property (IP) considerations are another dynamic that influences R&D and ROI. IP can lead to a 'Catch 22' when it comes to establishing R&D initiatives, particularly with respect to decisions on how you identify IP, whether to protect it, who should own it and how do you control it (not ignoring the costs involved).[15] Therefore, a flexible, open approach to creating a win-win scenario on IP should be the goal between research service providers and sponsors (if the R&D is contracted out). A share of benefits agreement is recommended at the outset, if IP is involved.

## ELECTRIC POWER R&D STRATEGY

The 'New Zealand Energy Strategy to 2050'[16] produced by the Ministry of Economic Development (MED) in October 2007 is intended to guide NZ towards a sustainable low emission energy system. Hence, much of the focus within the strategy in terms of R&D is to reduce carbon emissions using renewable technologies and electric vehicles, which are challenges that inherently must be overcome by engineers. It is disturbing to note that the keywords 'engineering' and 'engineers' do not appear within this 112 page document. The emphasis instead appears to be on fundamental science and science capability in NZ, i.e. the role of engineers and engineering appears to have been overlooked within the context of this strategy.

***Engineering vs. Science:***

*Engineering by definition is 'the application of scientific and mathematical principles to practical ends', while science is defined as 'the systematic knowledge of the physical or material world gained through observation and experimentation'.[17] Therefore, while scientists explore nature in order to discover general principles, engineers apply established principles drawn from mathematics and science in order to develop economically viable solutions.[18] Hence, the process of engineering is a key ingredient of R&D.*

There is a target of 90% renewable generation in NZ by 2025. However, it is regarded as being unlikely to be achieved using wind power alone, without the commissioning of new hydro generation in the next decade or more, a difficult scenario.[19] The canned $1.2 billion Project Aqua hydro scheme on the Waitaki river in 2004 would certainly have had a positive impact on this target, if it had gone ahead.[20] To add to this, the integration of increased wind generation connected to networks is likely to cause the most concern for the electricity industry in the coming years. This is mainly due to the intermittent nature of wind generation. Specific factors include frequency management, variable output, generation scheduling and standards to guide integration.[21] These issues should be researched within the context of the 'actual' NZ system (i.e. modelled on NZ conditions) to generate solutions. Overseas R&D solutions will not provide specific answers.

Similarly in Europe, the discussion over the integration of renewable energies and distributed generation is also causing great distress. In response, the EU is pursuing the creation of a new technology platform, dubbed 'SmartGrids'. The initial scope of the 'SmartGrids' platform is to increase the efficiency, safety and reliability of European electricity transmission and distribution networks, and remove obstacles to large scale integration of distributed and renewable energy. Furthermore, the EU document for the 'SmartGrids' initiative has many occurrences of the keywords 'engineering' and 'engineers'.[22] The intention of this document is to pave the way for future R&D activities by establishing the framework for collaboration, funding and implementation, a model which could be simplified and adopted by NZ via groups such as the EEA on behalf of the electricity industry, with the support of organisations such as the Electric Power Engineering Centre (EPECentre) to undertake actual R&D. Note: other entities that undertake research in this area includes IRL (Industrial Research Limited) and the CAE (Centre for Advanced Engineering) - both have a more general focus, not specific to electric power.

From the experience of the EPECentre, two critical areas in the NZ electricity industry requiring rigorous and focused industry-academia collaborative R&D are (1.) network integration of renewable energy generation and (2.) affects of loads on networks (particularly power quality issues). From the perspective of government, the focus instead tends to be on more applied blue sky's type research into developing energy technologies, such as wave power and a hydrogen economy,[1] areas which have experienced decades of multi-million-dollar R&D investment overseas with very few results. For example, hydrogen has been labelled by many experts as the least efficient and most expensive possible replacement for petrol.[23] Hence, there appears to be misalignment between priority areas for R&D between government and electricity industry.

Overall, the annual expenditure of $18 million p.a.[16] (1% of GDP) on energy (including electricity) R&D from the public sector in NZ is significantly lower than that for other sectors, such as the primary production sector, which is currently $396 million p.a.[24].

However, the cause for concern should be more on the mismatch involving the priority areas for energy research between electricity industry and government.

**The Electric Power Engineering Centre:**
The EPECentre (www.epecentre.ac.nz) is NZ's Centre of Excellence for electric power engineering, sponsored by the power industry (via the Power Engineering Excellence Trust (PEET), www.epecentre.ac.nz/peet) and hosted within the University of Canterbury. It was established in 2002 to create a link between electric power academia and industry to foster and support power engineering education, industry-academia interaction, research and innovation in NZ. The centre now has a dedicated team of R&D specialist engineers that work in collaboration with industry-academia in the areas of power systems, power applications, high voltage, renewable energy and power electronics. The centre also provides full R&D project management services and facilitation for joint industry-academia R&D projects and programmes, including applications for funding and project proposal preparation.

The EPECentre is governed by a pan-industry board that represents each sector of the industry, from generation, transmission and distribution, right through to consulting, contracting, professional engineering and academia. It currently has over 30 industry partnerships, the largest industry linkages for an entity within the University of Canterbury, and has dramatically increased electric power graduate numbers entering the NZ electricity industry over the last 5 years (against international trends). As a testament to this, the EPECentre received recognition for its achievements as a successful model for industry-academia collaboration at the CIGRÉ (International Council on Large Electric Systems) Paris Session in 2006. Furthermore, the electric power engineering programme at the University of Canterbury (enhanced/supported by the EPECentre) is now considered one of the 'best' in Australasia. The centre also launched NZ's first industry-academia collaborative R&D programme in 2005 and has since successfully completed over 25 collaborative R&D projects for industry. Clients have included Transpower, Orion, Meridian Energy, Antarctica NZ and ElectraNet SA.

## PUBLIC FUNDING FOR POWER R&D IN NZ

In terms of support, a number of public schemes exist to support R&D in energy, such as tax credits and joint industry-government co-funding mechanisms, as shown in Table 1.

| Agency | Type | Details |
|---|---|---|
| IRD (Inland Revenue Department) | R&D tax credits | 15% tax credit for business R&D expenditure (some exclusions apply) |
| FRST (Foundation for Research Science & Technology) | Co-funding / contestable funding / support funding Note: expected level of investment is typically a ratio of 20:80 (industry to government funding, respectively) | Optimising Physical Resource Use and Infrastructure Services (ORI) portfolio; funding is $4.1 million in 2007/08. Note: a new contestable fund worth $12 million has also been proposed to support low carbon energy technologies. While, TechNZ is another scheme that supports R&D related internships and temporary secondments, as well as seed funding. |
| EECA (Energy Efficiency Conservation Authority) | Contestable funding for R&D | Contestable fund of $8 million over four years from Oct 2007 onwards. |
| MED (Ministry of Economic Development) | Facilitates support for R&D | Works with other agencies such as FRST to enhance government assistance for R&D.[25] |
| NZTE (NZ Trade & Enterprise) | Facilitate participation in international research / co-funding | Growth Services Fund (GSF) and Enterprise Development Grants (EDG) ~ for general R&D, not specific to electric power. |

***Table 1. Major R&D public funding/support schemes eligible for electric power research[16]****

*Note: there are strict eligibility criteria for the schemes shown in Table 1; projects should be assessed on a case-by-case basis for funding opportunities.

The EPECentre is registered via the University of Canterbury as a listed research provider, which enables worked performed by the EPECentre for clients to be eligible for R&D tax credits, if other criteria are met.[26] According to a 2007 survey, only 53% of NZ businesses are aware of the R&D tax credit.[27] The IRD has a comprehensive online document that outlines the eligibility criteria (www.ird.govt.nz).[29] On the other-hand, by far the largest public funding body for R&D expenditure in NZ is FRST (Foundation for Research Science & Technology).

FRST has a number of portfolios for R&D funding. However, only one of these is directly applicable to the electricity industry, the Optimising Physical Resource Use and Infrastructure Services (ORI) portfolio. This portfolio aims to support research that is related to improving energy management and infrastructure, through a two-stage contestable process.[28] Projects supported can be short-term (up to 3 years) or medium-term (up to 6 years), must be collaborative in nature for the benefit of industry and fit within the priority areas identified by FRST. The EPECentre is currently awaiting confirmation from FRST on two FRST industry-academia collaborative R&D proposals that are in the 2nd stage of this process.

## R&D PROJECT MANAGEMENT

R&D project management requires rigorous planning and its implementation requires certain considerations. However, much of the process is not too dissimilar to standard projects, with the addition of unique risk mitigation and management techniques.

In terms of a project life-cycle model, uncertainty or significance of decisions or degree of freedom to manoeuvre is highest at the start of a project and lowest nearing the end. Conversely, accumulated costs or available information and cost of changes is lowest at the start and highest nearing the end (note: this holds true for both R&D and non-R&D projects).[29] Therefore, stage gating of R&D projects into smaller workable components is generally good practice for risk mitigation. This will inherently reduce project sensitiveness to failure mechanisms.

Consequently, some of the main reasons why projects fail or incur delays,[30] in an R&D context includes unrealistic budgets, deliverables or schedules, scope changes without stakeholder or sponsor involvement; gold plating of deliverables and inflexibility of scope (i.e. too rigid and unsuitable for R&D). The long wait for approvals in hierarchical organisations can also delay projects and miss opportunities for progress. Other factors include not keeping stakeholders in the loop and fear of failure, combined with pressures on ROI, technology limitations or complexity of solutions, having the wrong people and general lack of flexibility.[31]

## RECOMMENDATIONS & CONCLUSIONS

There is a misalignment between industry and government priority areas for R&D. Hence, improved engagement between the power industry and government agencies such as FRST is recommended. One option could be the creation of a joint electric power industry-academia R&D advisory group to interact (annually) with government agencies on vital R&D topics for the power system in NZ. This group could be established this year and coordinated through the EPECentre on behalf of industry and academia. Furthermore, the $700 million set aside by the government to support primary sector R&D should be rerouted and be made available for all sectors/industries (including the primary sector) to enable flexible R&D, to build towards a future 'knowledge-based economy' in NZ. In comparison, the EU seems to have better alignment between R&D priorities for both the power industry and government. They are in the process of setting up the 'SmartGrids' model to enable R&D. However, NZ has a head-start with the launch of NZ's first industry-collaborative electric power R&D programme by the EPECentre in 2005. The foundation has been established by the EPECentre and it now has the experience and capability to undertake significant 'industry led' R&D over the coming years. Potential R&D projects also have the opportunity to tap into a range of funding schemes and incentives available via the government, which spends around $18 million p.a. on energy research. Nevertheless, the NZ electricity industry appears to be financially strong and more than capable of undertaking such activity on its own, on targeted priority issues, without the need for public sector R&D funding.

Moreover, the long-term impact of not prioritising solutions for 'real' electricity issues (as deemed by the power industry) is likely to be detrimental to the economy, the country, the people and our way of life –*"electric power research in NZ, disconnected from direct industry needs, will not provide the answers for the quality of electricity supply in the future"*.

***"New Zealand's Centre of Excellence for Electric Power Engineering"***

*www.epecentre.ac.nz*

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